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Best Pricing Strategy for Information Services*

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Abstract

This paper examines which of three commonly-used pricing schemes – flat fee pricing, pure usage-based pricing, and two-part tariff pricing – is optimal for a monopolist providing information services. Our analysis suggests that under zero marginal costs and monitoring costs, when customers are homogeneous or when customers have different downward sloping demand curves, flat fee pricing and two-part tariff pricing achieve the same profit level, and dominate usage-based pricing. However, when customers are characterized by heterogeneous maximum consumption levels, the two-part tariff pricing is the most profitable among the three. We also examine how sensitive the optimal pricing scheme is to marginal costs and monitoring costs. Our analysis shows that when the sum of the marginal costs and the monitoring costs is below a threshold value, flat fee pricing is the optimal scheme regardless of how large or how small the monitoring costs are (as long as they are positive) when customers are homogeneous or have heterogeneous marginal willingness to pay. Positive marginal costs also do not change this result; but when monitoring costs are zero, the two-part tariff becomes one of the optimal pricing schemes.

Keywords: *Information Services Pricing, Flat Fee Pricing, Pure Usage-Based Pricing, Two-Part Tariff*

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1. Introduction

In this paper, we examine the optimal pricing scheme for a monopoly information service provider who provides one kind of information service. Contrary to common impression, there are actually quite a few monopoly information service providers that we can observe. For example, the different services provided by the leading social networking sites like MySpace, Facebook, and Twitter successfully make their businesses unique in some way and somehow secure a monopoly position in their own domain. The uniqueness of Second Life also makes it a monopolist in its market. These sites provided their services to the general public for free in the early stages of their businesses. Their strategic reasons for doing so were perhaps to attract traffic and adopt the advertising-supported business model. They may charge their users for services provided in the future once enough users are addicted to their services; for example, Twitter Japan was thinking about charging their customers at the end of 2009.

There are also examples of monopoly information service providers who have charged fees for their services since the establishment of their businesses. In many regions, there is just one cable TV provider that has taken advantage of its monopoly power. Both the Consumer Federation of America and Consumers Union, the publisher of *Consumer Reports* magazine, have criticized such companies for their poor services and skyrocketing cable rates in recent years. Gogo Inflight Internet has successfully created a monopoly environment on airplanes where its services are offered, since customers do not have any other Internet connection choice while they are in the air. Similarly, the Internet connection services provided on many cruise ships are also examples of monopoly information services providers who charge fees.

One of the most salient and unique characteristics of information services is that with enough capacity, the marginal cost of providing the services is negligible (near zero or zero). This makes flat fee pricing attractive and viable, as has been argued by many researchers (e.g., Oi, 1971; Fishburn et al., 1997). While traditional nonlinear pricing theory (Maskin and Riley, 1984; Wilson, 1993; Armstrong, 1996) has suggested that the optimal pricing strategy for a monopolist is strictly based on usage, and many researchers strongly advocate the optimality of two-part tariff pricing (Oi, 1971; Schmalensee, 1981; Calem and Spulber, 1984; Hayes, 1987; Stole, 1995; Armstrong and Vickers, 2001; Rochet and Stole, 2002), the results to date have been based on the assumption that there is a relatively high marginal cost of production. This is actually why almost all, if not all, utilities services firms adopt usage-based pricing (with or without a subscription fee). For some of the exceptions we have observed, there are usually other reasons why flat fee pricing has been adopted. For example, there may be no monitoring facility available, or the monitoring facilities may be too expensive to install and use for individual users.

While some argue that negligible marginal production cost makes flat fee pricing more profitable for information services (Fishburn et al., 1997), some researchers believe that diminished monitoring or distribution costs make usage-based pricing a relatively more attractive option for information services (Choi et al., 1997; Metcalfe, 1997). There is so far no clear guidance about when information service providers should adopt flat fee pricing and when pure usage-based pricing (without a subscription fee) or even a two-part tariff (usage-based pricing plus a subscription fee) is more profitable. Many information service providers have struggled to find the best ways to price their services and bill their customers, and this is reflected in the wide variety of pricing schemes offered by different information service providers.

Specifically, we are interested in knowing which among the three most popular pricing schemes used in practice – flat fee pricing, usage-based pricing, and two-part tariff pricing – is the best for a monopolist providing information services. Overall, our analysis suggests that under conditions of zero marginal and monitoring costs, when customers are homogeneous or when customers have heterogeneous marginal willingness to pay (which corresponds to different downward sloping demand curves), flat fee pricing and two-part tariff pricing always achieve the same profit level, and are strictly better than the usage-based pricing. However, when customers are characterized by heterogeneous maximum consumption levels, two-part tariff pricing is the most profitable among the three. We also examine how sensitive the optimal pricing scheme is to marginal costs and monitoring costs when customers are homogeneous or when customers have heterogeneous marginal willingness to pay. Our analysis shows that when the sum of the marginal cost and the monitoring cost is below a certain value, flat fee pricing is the optimal scheme regardless of how large or how small monitoring cost is (as long as it is positive) when customers are homogeneous or have heterogeneous marginal willingness to pay. Even increasing marginal cost does not change this result. Nevertheless, when monitoring cost is zero, the two-part tariff becomes one of the optimal pricing schemes.

The paper is organized as follows: In Section 2, we review the information service pricing literature. In Section 3, we provide the general model for the market for information services. Section 4 reports on the analysis of different pricing schemes and when they are the best choice for the information service provider. Section 5 outlines some model extensions. We provide concluding remarks and a discussion of our results in Section 6.

2. Literature Review

While there has been increasing interest in how to price *information goods*, like software, digital songs, or movies (Bakos and Brynjolfsson, 1999; Chuang and Sirbu, 1999; Varian, 2000), much of the work either does not address information services, or is only indirectly applicable to such cases. For example, the advantages of pure bundling documented in Bakos and Brynjolfsson (1999) and customized bundling documented in Wu et al. (2008) result from reduction in the variance of customers' valuations for a bundle of *different* information goods. These modeling techniques cannot be applied to information services, since each unit of information services is essentially identical[1] and, therefore, we cannot expect variance to be reduced through aggregation of *identical* units. In this paper, we use a framework in which both buyers and sellers of information services optimize value in order to determine which pricing scheme works best under different conditions.

Recent works that are related to information service pricing include Fishburn et al. (1997), Essegaier et al. (2002), and Sundararajan (2004). Our paper is complementary to these papers. Sundararajan (2004) considers fixed-fee and nonlinear usage-based pricing schemes. However, the focus of his study is different from ours in this paper. He shows that in the presence of contract administration costs, such as monitoring costs for usage-based pricing, a monopolist can improve its profits by offering fixed-fee pricing in addition to a usage-based contract. However, while this study has suggested that a firm could improve its profits by adopting a mix of pricing schemes, the results are based on a utility function that has to satisfy the Spence-Mirrlees single-crossing property (Fudenberg and Tirole, 1993), which allows a firm to possibly segment customers profitably through their self-selection. When this property does not hold, it is not clear whether adopting multiple schemes will still improve profit.

In addition, Sundararajan (2004) does not offer any direct guidance about which pricing scheme is most profitable when the firm can only opt for one pricing scheme, the major focus of our paper. There are several situations where firms may prefer to adopt only one pricing scheme. For example, when a *new* information service is being introduced in the market, the firm may prefer to adopt only one pricing scheme to keep the marketing simple; easier administration and management may also make the firm prefer one pricing scheme only (Curle, 1998; Wilson, 1993).

Moreover, it is actually common in the literature to assume the monopolist will choose a single pricing scheme, like in Essegaier et al. (2002), Masuda and Whang (2006), and Fishburn et al. (1997). It is also a common practice in real life. We observe only a few instances of sophisticated nonlinear pricing in practice and find mostly very simple pricing schemes in wide use. For example, Verizon has chosen just the flat fee pricing scheme for its DSL high-speed Internet service and E*TRADE charges commissions based solely on the number of trades placed by the customers, which is an example of pure usage-based pricing. Another simple pricing scheme is that adopted by SingTel, which charges users of its telephone line services in Singapore a quarterly subscription fee, plus unit call charges. This is a two-part tariff scheme.

[1] Thus, they will have perfect correlation across units in customers' valuations.

Fishburn et al. (1997) compare the flat fee and the usage-based pricing and show that a flat fee is better than a metered rate for a monopolist offering information services on the Internet. However, they simplify the problem with some very restrictive assumptions. For example, they assume that consumers choose the quantity of service to buy and stick to it *before* examining the available prices. It is not clear whether their results could be generalized to more general demand functions, for example, a downward sloping demand function.

We differ from Sundararajan (2004) and Fishburn et al. (1997) in considering two-part tariff pricing, which is popular both in theory and in practice. Essegaier et al. (2002) also consider the two-part tariff pricing together with flat fee and usage-based pricing. However, as in Fishburn et al. (1997), they assume that consumer usage is inelastic to price changes. Moreover, they assume that both heavy and light users have the same total reservation price for the service. This may be a questionable assumption, as users usually have quite different and diminishing marginal utility for each unit of service they consume.[2] It is also questionable to assume that marginal cost is zero when the service provider has a capacity constraint. (Another problem with capacity constraint is the possible queuing problems, which is not discussed in their paper.)

Table 1 below summarizes these recent studies.

Table 1: Summary of Some Recent Research Including This Paper

	Major Assumptions	Major Finding
Fishburn et al. (1997)	The firm prefers to adopt only one pricing scheme. Consider flat fee and usage-based pricing. Consumers choose the quantity of service to buy and stick to it *before* examining the available prices.	Flat fee pricing is better than a metered rate for a monopolist.
Essegaier et al. (2002)	The firm prefers to adopt only one pricing scheme. Consider two-part tariff pricing together with flat fee and usage-based pricing. Consumer usage is inelastic to price change. Both heavy and light users have the same total reservation price for the service. Marginal cost is zero when there is capacity constraint.	Flat fee pricing is a sustainable pricing structure once the industry has sufficient capacity.
Sundararajan (2004)	The firm is willing to adopt a mix of pricing schemes. Consider flat fee and nonlinear usage-based pricing. Employs a utility function that satisfies the Spence-Mirrlees single-crossing property.	A firm can improve its profits by adopting a mix of pricing schemes.
This paper	The firm prefers to adopt only one pricing scheme. Two-part tariff pricing, flat fee pricing and usage-based pricing. Employs a downward sloping demand function.	Either flat fee pricing or the two-part tariff is the optimal pricing scheme, depending on different conditions.

3. Market Model for Information Services

In this paper, we consider the three most commonly-used pricing schemes: pure flat fee pricing, pure usage-based pricing, and two-part tariff pricing. The monopoly information service provider chooses which pricing scheme to adopt and the prices to offer. Consumers then make decisions about

[2] Although they extend their model by using the same unit reservation price for the two consumer segments, their assumption still fails to reflect the fact that users usually have quite different and diminishing marginal utility for each unit of service they consume.

whether to join the plan, and how much to consume given the pricing scheme and prices set by the monopoly information service provider.

Since some information services usually experience some peak hours and some non-peak hours, we assume that consumers may have different utility functions during these times. As a result, information service providers may charge different prices for the two time segments when using usage-based pricing. For example, many telephone service providers like SingTel in Singapore still charge different unit prices for peak and non-peak hours. Note this assumption does not limit but rather enriches our model. It is because if consumers actually have the same utility functions in peak hours and non-peak hours, our model can accommodate these different settings and the provider can always charge the same price for the two time segments and treat them equally, if it wishes to.

In addition, because consumers have limited time, energy, attention, and diminishing marginal utility, we assume that they face certain upper bounds in consuming the services. This is a reasonable assumption, as almost all, if not all, information services have this property, and no single consumer can continue to consume one information service without any limit. For example, consumers cannot consume a time-based information service like voice communication for more than 24 hours a day. Given the limited transmission rate of the device used, the traffic volume in each period is also naturally bounded for any data transmission service. The number of trades through E*TRADE and Short Messaging Services (SMS) / Multimedia Messaging Service (MMS) have the same property as the number of trades or uses in each period being bounded above at least by the total time available, given a positive time requirement to complete each trade or use.

3.1. The Consumer's Optimization Problem

Given the pricing scheme (flat fee, usage-based, or two-part tariff) and price(s) set by the information service provider, consumer *i* will decide whether or not she wants to join the service program (i.e., to buy the information service) and what her consumption level of the service will be in both peak hours and non-peak hours to maximize her total net utility.

Given Parameters:

P : the subscription fee for the consumer to join the program

P_X : the unit price of the service set by the provider in peak hours

P_Y : the unit price of the service set by the provider in non-peak hours

$U_i\left(X_i, Y_i\right)$: the utility function of consumer i at the consumption level of X_i in peak hours and Y_i in non-peak hours

$\overline{X}_i$: consumer i's maximum consumption level of the service in peak hours

$\overline{Y}_i$: consumer i's maximum consumption level of the service in non-peak hours

Decision Variables:

X_i : consumer i's consumption level of the service in peak hours

Y_i : consumer i's consumption level of the service in non-peak hours

Z_i : the decision variable which is 1 if consumer i chooses to join the program and 0 otherwise

Consumer's Optimization Problem:

$$\underset{X_i, Y_i, Z_i}{\text{Max}}\ U_i\left(X_i, Y_i\right) - P_X X_i - P_Y Y_i - PZ_i \qquad (1)$$

s.t.

$$X_i \leq \overline{X}_i\ Z_i \qquad (2)$$

$$Y_i \leq \overline{Y}_i\ Z_i \qquad (3)$$

$$U_i\left(X_i, Y_i\right) - P_X X_i - P_Y Y_i - PZ_i \geq 0 \qquad (4)$$

(The Individual Rationality constraints)

$$Z_i = 0 \text{ or } 1 \qquad (5)$$

The objective function (1) is to maximize the consumer surplus given the price(s) set up by the information service provider. Similar to the concept of maximizing net profit (revenue minus cost) for the firms, the assumption of maximizing consumer surplus (utility minus cost) for consumers is a standard set-up in consumer decision modeling and is widely adopted in the literature (e.g., Armstrong, 1996; Fishburn et al., 1997; Sundararajan, 2004; Masuda and Whang, 2006; Wu and Chen, 2008; Wu et al., 2008). In our model, we do not consider the initial cost for the consumer to join the program, such as the purchase of 3G mobile devices in the 3G wireless service scenarios, for two reasons. First, when we consider the long-term relationship between the supplier and consumers, this kind of one-time expense may not be as important as the monthly usage fee and the subscription fee. Further, this one-time fee does not affect the optimization problem, and it can be absorbed by $U_i\left(X_i, Y_i\right)$.

Note also that there is no parameter in this model that indicates the pricing scheme adopted by the information service provider. Rather than using an additional parameter to indicate the pricing mechanism, the pricing scheme chosen actually is reflected by the values of P_X, P_Y, and P. For example, when P_X and P_Y are both zero and P is positive, it is pure flat fee pricing; when P_X and P_Y are positive and P is zero, we have pure usage-based pricing; and when P_X, P_Y, and P are all positive, two-part tariff pricing is being represented. Additionally, in this paper, we consider the simplest and most commonly adopted usage-based and two-part tariff pricing in which the unit price of the service is constant and does not change with the consumer's consumption level. For example, almost all, if not all, residential long distance voice communication services (with or without a monthly fee) and wireless data transmission services have a constant unit price.

Given P_X, P_Y, and P, consumer *i* will decide if she wants to join the program. If she decides not to join by choosing $Z_i = 0$, constraints (2) and (3) will force her consumption levels X_i and Y_i to be zero, and her total utility and cost are both zero. On the other hand, if she decides to join the program and chooses $Z_i = 1$, she then has to decide her optimal consumption levels X_i and Y_i, which cannot exceed her upper bounds $\overline{X_i}$ and $\overline{Y_i}$, as enforced by constraints (2) and (3). Also note that the consumption levels X_i and Y_i here could be the consumption time, such as in voice communication services, or the traffic volume in data transmission services, or the number of trades through online discount brokers, or the number of messages sent in SMS/MMS services.

3.2. The Supplier's Optimization Problem

Given the optimization problem faced by the consumers, the information service provider will decide what pricing scheme to adopt to maximize its total profit. We assume that marginal production cost for providing one more unit of the service to the customer, and monitoring cost for one unit of the service in usage-based pricing[3] are both negligible or zero. We will discuss this assumption in Section 5.

Given Parameters:

$X_i{*} = X_i(P_X, P_Y, P)$: consumer *i*'s consumption level of the service in peak hours

$Y_i{*} = Y_i(P_X, P_Y, P)$: consumer *i*'s consumption level of the service in non-peak hours

$Z_i{*} = Z_i(P_X, P_Y, P)$: consumer *i*'s decision variable regarding participation

$U_i\left(X_i, Y_i\right)$: the utility function of consumer i at the consumption level of X_i in peak hours and Y_i in non-peak hours

$\overline{X_i}$: consumer *i*'s maximum consumption level of the service in peak hours

$\overline{Y_i}$: consumer *i*'s maximum consumption level of the service in non-peak hours

Decision Variables:

[3] Since there is no need to monitor the customer usage level in flat fee pricing, we assume that flat fee pricing does not incur monitoring cost in the analyses throughout.

P : the subscription fee for the consumer to join the program
P_X : the unit price of the service set by the provider in peak hours
P_Y : the unit price of the service set by the provider in non-peak hours

The Supplier's Optimization Problem:

$$\underset{P,P_X,P_Y}{\mathrm{Max}} \sum_i \left(P_X X_i{}^* + P_Y Y_i{}^* + P Z_i{}^*\right) \qquad (6)$$

where $(X_i{}^*, Y_i{}^*, Z_i{}^*)$ = argmax $U_i\left(X_i, Y_i\right) - P_X X_i - P_Y Y_i - P Z_i$

s.t.

$$X_i \le \overline{X_i}\ Z_i$$

$$Y_i \le \overline{Y_i}\ Z_i$$

$$U_i\left(X_i, Y_i\right) - P_X X_i - P_Y Y_i - P Z_i \ge 0$$

$$Z_i = 0 \text{ or } 1$$

The objective function (6) is to maximize the total profit given the optimization problems faced by the consumers. Note that we do not consider the initial fixed cost of providing the service to each consumer, as it is not as important if we consider the long-term relationship between the supplier and consumers. And this is perhaps why we see many wireless service providers offering free phones to attract new long-term customers.

In addition, like in Sundararajan (2004) and Fishburn et al. (1997), we assume the service provider has enough capacity, so the marginal cost of providing the service is zero. Note that given any capacity, we can assume the marginal cost within capacity is zero. A firm only faces large "marginal cost" when it needs to increase capacity, but this is actually another investment decision made by the firm, rather than the marginal cost of the service, because with new larger capacity, marginal cost goes to zero again. In fact, in real life, as the costs of IT and communication equipment keep dropping every year, it is relatively easy and cheap for the information service providers to increase their capacity if they see the need. For example, personal communication services (PCS) carriers usually have negligible marginal cost, as they have large unused networks (PCS Week 1997). As a result, we think it is a reasonable assumption that the service provider can always maintain enough capacity and keep the marginal cost at zero. Based on this model, we can find the most profitable pricing scheme and price(s) to charge the consumers given the consumers the provider faces.

4. Analysis

4.1. The Base Case: Homogeneous Consumers

As the first case, we consider homogeneous consumers in the market with the same utility function and the same upper bounds $\overline{X}$ and $\overline{Y}$ on the consumption level in peak hours and non-peak hours, respectively. For analytical convenience, we adopt the frequently used Cobb-Douglas type of utility function (Pindyck and Rubinfeld, 1998), $U\left(X,Y\right) = a\log X + b\log Y$, with one minor modification:[4]

$$U\left(X,Y\right) = a\log\left(X+1\right) + b\log\left(Y+1\right) \qquad (7)$$

With this modification, when the consumption level is zero, consumers will get zero utility rather than negative infinity as utility. Note that this utility function is increasing and strictly concave in consumption level and that X and Y are substitutes in that one could substitute one for the other to get the same utility. We adopt this specific utility function for two reasons: It not only greatly simplifies our derivations but also allow us to explore how the homogeneity (in this subsection) and heterogeneity (in Subsection 4.2.) of consumer utility functions (with diminishing marginal utility

[4] Log denotes natural log here.

property) affect a firm's choice of pricing structure. Using the general form of utility function $U_i\left(X_i, Y_i\right)$ would make our analysis much less tractable and less transparent without any apparent promise for new insights. Note also that this model could accommodate the case when consumers have the same utility for the two time segments. We can do this by setting *a* equal to *b*, so the service provider treats the two time segments as the same.

With this specific utility function, each consumer will then face the following optimization problem:

Consumer's Optimization Problem:

$$\underset{X,Y,Z}{\text{Max}}\ a\log\left(X+1\right)+b\log(Y+1)-P_X X-P_Y Y-PZ \qquad (8)$$

s.t.

$$X \le \overline{X}\ Z \qquad (9)$$

$$Y \le \overline{Y}\ Z \qquad (10)$$

$$a\log\left(X+1\right)+b\log(Y+1)-P_X X-P_Y Y-PZ \ge 0 \qquad (11)$$

$$Z = 0 \ \text{ or } \ 1 \qquad (12)$$

In the consumer's optimization problem, the information service provider tries to solve the following optimization problem:

The Supplier's Optimization Problem:

$$\underset{P_X,P_Y,P}{\text{Max}}\ \sum_i \left(P_X X^* + P_Y Y^* + PZ^*\right) \qquad (13)$$

where (X^*, Y^*, Z^*) = argmax $a\log\left(X+1\right)+b\log(Y+1)-P_X X-P_Y Y-PZ$

s.t.

$$X \le \overline{X}\ Z$$

$$Y \le \overline{Y}\ Z$$

$$a\log\left(X+1\right)+b\log(Y+1)-P_X X-P_Y Y-PZ \ge 0$$

$$Z = 0 \ \text{ or } \ 1$$

To solve the supplier's optimization problem, we make the following observations: First, since all consumers are assumed to be homogeneous, all consumers will make the same "join" or "not join" decision, and the service provider either will serve all of them or will serve none of them. In order to maximize profit, the service provider will make sure that all consumers want to join the program. Second, since the major pricing mechanisms we are studying in this paper are pure flat fee, pure usage-based, and two-part tariff pricing, we can do the analysis separately and see what is the best profit the service provider can get by each pricing plan.

Lemma 1: if the service provider uses the pure flat fee, the price charged will be *a* log($\overline{X}$ +1) + *b* log($\overline{Y}$ +1) (for the peak hour problem, it is the whole area below curve *D* in Figure 1), and the maximum profit achievable will be $\sum_i$ [*a* log($\overline{X}$ +1) + *b* log($\overline{Y}$ +1)].

Proof: See the Appendix.

Lemma 2: If the service provider uses the pure usage-based pricing, the optimal prices will be $P_X = \frac{a}{\overline{X}+1}$ (see Figure 1) and $P_Y = \frac{b}{\overline{Y}+1}$, with maximum profit: $\sum_i$ (*a* - $\frac{a}{\overline{X}+1}$ + *b* - $\frac{b}{\overline{Y}+1}$) = $\sum_i$ [*a*(1 - $\frac{1}{\overline{X}+1}$) + *b*(1 - $\frac{1}{\overline{Y}+1}$)].

Proof: See the Appendix.

Lemma 3: If the service provider uses the two-part tariff pricing, the best P_X and P_Y will be $P_X = \frac{a}{\overline{X}+1}$ and $P_Y = \frac{b}{\overline{Y}+1}$. The maximum subscription fee *P* the supplier can charge is the difference between the maximum utility the consumers can get, *a* log($\overline{X}$ +1) + *b* log($\overline{Y}$ +1), and the payment for their usage, (*a* - $\frac{a}{\overline{X}+1}$ + *b* - $\frac{b}{\overline{Y}+1}$) (for the peak hour problem, it is the triangular area below curve *D* and above $\frac{a}{\overline{X}+1}$ in Figure 1). Therefore, the maximum profit achievable by the service provider is $\sum_i$ [*a* log($\overline{X}$ +1) + *b* log($\overline{Y}$ +1)]

Proof: See the Appendix.

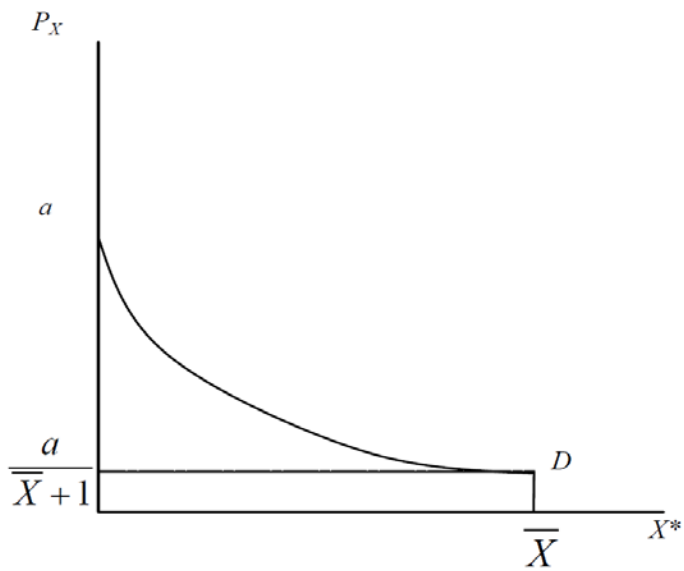

Figure 1: Homogeneous Consumers

From Lemmas 1 to 3, note that since log($\overline{X}$ +1) > (1 - $\frac{1}{\overline{X}+1}$) and log($\overline{Y}$ +1)> (1 - $\frac{1}{\overline{Y}+1}$) for all $\overline{X}, \overline{Y} > 0$, we have *a* log($\overline{X}$ +1) + *b* log($\overline{Y}$ +1)> [*a*(1 - $\frac{1}{\overline{X}+1}$) + *b*(1 - $\frac{1}{\overline{Y}+1}$)]. That is, the pure flat fee pricing and the two-part tariff pricing yield the same profit and are strictly better than the pure usage-based pricing from the service provider's profit maximization point of view.

This result is consistent with the argument that since the marginal cost is negligible for information services, flat fee pricing is more viable and attractive. In fact, because serving one more unit of the services will not increase costs for the information service provider, the information service provider has the incentive to attract as many customers as possible to the plan and provide all-you-can-consume services while using the flat fee pricing to extract all of the consumer surplus. Traditional nonlinear pricing theory has advocated the optimality of two-part tariffs. It has also suggested that the monopolist should set the unit usage price at the marginal cost and use the subscription fee to extract the remaining consumer surplus. This pricing scheme remains the most appropriate when the marginal cost and the monitoring cost are both negligible. From our analysis, we can clearly see that the information service provider should still try to match the unit usage price to the marginal cost by lowering the unit usage price. However, while the marginal cost is zero, and the consumption levels for the information services are naturally bounded, the information service provider will realize that there is no need to lower the unit usage price further and will stop at the point when the consumers' consumption levels will not increase further because of the unit usage price drop. In spite of this, the subscription fee can still successfully extract the remaining consumer surplus and achieve the same profit level for the information service provider as in the case when the information service provider adopts the flat fee pricing mechanism. However, because the pure usage-based pricing lacks this flexibility, it cannot extract the remaining consumer surplus while the unit usage price is reduced to the same level as in the case of the two-part tariff.

4.2. Heterogeneous Customers

In the previous analysis, we showed that flat fee pricing and two-part tariff pricing are more profitable than pure usage-based pricing. However, the assumption of homogeneous consumers may be somewhat restrictive, so we relax this assumption by considering different types of heterogeneous customers. Following Jain et al. (1999), we examine two sets of customer segmentation: "high-end" and "low-end" in terms of willingness-to-pay (Subsection 4.2.1.), and "heavy" and "light" in terms of level of usage (Subsection 4.2.2.). We further assume that it is in the firm's interest to serve both segments in each case; otherwise, the problem is reduced to that considered in Subsection 4.1. We also assume that the information service provider cannot discriminate between these two consumer segments. This assumption is reasonable since it is usually hard for the service provider to tell what segment the consumers belong to. Note that if the information service provider can discriminate between these two types of consumers, the problem is similar to that in Subsection 4.1., and the information service provider can simply offer different flat fee pricing or two-part tariff pricing to different consumer segments.

4.2.1. Heterogeneous customers: the high-end customers and the low-end customers

We suppose there are *m* high-end consumers (*i*=1) and *n* low-end consumers (*i*=2). To study how heterogeneous willingness to pay affects a firm's pricing scheme, we assume each consumer in both segments has the same upper bounds $\overline{X}$ and $\overline{Y}$ in peak hours and non-peak hours, and $a_1 > a_2$, $b_1 > b_2$.

Consumer's Optimization Problem:

$$\underset{X_i, Y_i, Z_i}{\text{Max}} \; a_i \log\left(X_i + 1\right) + b_i \log(Y_i + 1) - P_X X_i - P_Y Y_i - PZ_i \quad (14)$$

s.t.

$$X_i \le \overline{X} \; Z_i \quad (15)$$

$$Y_i \le \overline{Y} \; Z_i \quad (16)$$

$$a_i \log\left(X_i + 1\right) + b_i \log(Y_i + 1) - P_X X_i - P_Y Y_i - PZ_i \ge 0 \quad (17)$$

$$Z_i = 0 \;\text{ or }\; 1 \quad (18)$$

The Supplier's Optimization Problem:

$$\underset{P_X, P_Y, P}{\text{Max}} \; m\left(P_X X_1{*} + P_Y Y_1{*} + PZ_1{*}\right) + n\left(P_X X_2{*} + P_Y Y_2{*} + PZ_2{*}\right) \quad (19)$$

where $(X_i{*}, Y_i{*}, Z_i{*})$ = $\text{argmax} \;\; a_i \log\left(X_i + 1\right) + b_i \log(Y_i + 1) - P_X X_i - P_Y Y_i - PZ_i$

s.t.

$$X_i \le \overline{X} \; Z_i$$

$$Y_i \le \overline{Y} \; Z_i$$

$$a_i \log\left(X_i + 1\right) + b_i \log(Y_i + 1) - P_X X_i - P_Y Y_i - PZ_i \ge 0$$

$$Z_i = 0 \;\text{ or }\; 1$$

Lemma 4: If the service provider uses the pure flat fee, the price charged will be $a_2 \log\left(\overline{X}+1\right)+b_2 \log\left(\overline{Y}+1\right)$ (for the peak hour problem, it is the whole area below curve D_2 in Figure 2), and the maximum profit achievable will be $(m+n)\left[a_2 \log\left(\overline{X}+1\right)+b_2 \log\left(\overline{Y}+1\right)\right]$.

Proof: See the Appendix.

Lemma 5: If the service provider uses the pure usage-based pricing, when $m\overline{X}>n$,[5] the optimal price in the peak hours is $P_X=\frac{a_1}{\overline{X}+1}$ (see Figure 2); when $m\overline{Y}>n$, the optimal non-peak hour price is $P_Y=\frac{b_1}{\overline{Y}+1}$. The maximum profit is $m(\frac{a_1\overline{X}}{\overline{X}+1}+\frac{b_1\overline{Y}}{\overline{Y}+1})+n(a_2-\frac{a_1}{\overline{X}+1}+b_2-\frac{b_1}{\overline{Y}+1})$; otherwise, the optimal prices are given by $P_X=\frac{a_2}{\overline{X}+1}$ (see Figure 2) and $P_Y=\frac{b_2}{\overline{Y}+1}$ with profit: $(m+n)(\frac{a_2\overline{X}}{\overline{X}+1}+\frac{b_2\overline{Y}}{\overline{Y}+1})$.

Proof: See the Appendix.

Lemma 6: If the service provider uses the two-part tariff pricing, the optimal P_X and P_Y will be $\frac{a_2}{\overline{X}+1}$ and $\frac{b_2}{\overline{Y}+1}$ respectively, and $P=a_2\log\left(\overline{X}+1\right)+b_2\log\left(\overline{Y}+1\right)-\frac{a_2\overline{X}}{\overline{X}+1}-\frac{b_2\overline{Y}}{\overline{Y}+1}$ (for the peak hour problem, it is the triangular area below curve D_2 and above $\frac{a_2}{\overline{X}+1}$ in Figure 2) with the maximum profit achievable: $(m+n)[a_2\log(\overline{X}+1)+b_2\log(\overline{Y}+1)]$.

Proof: See the Appendix.

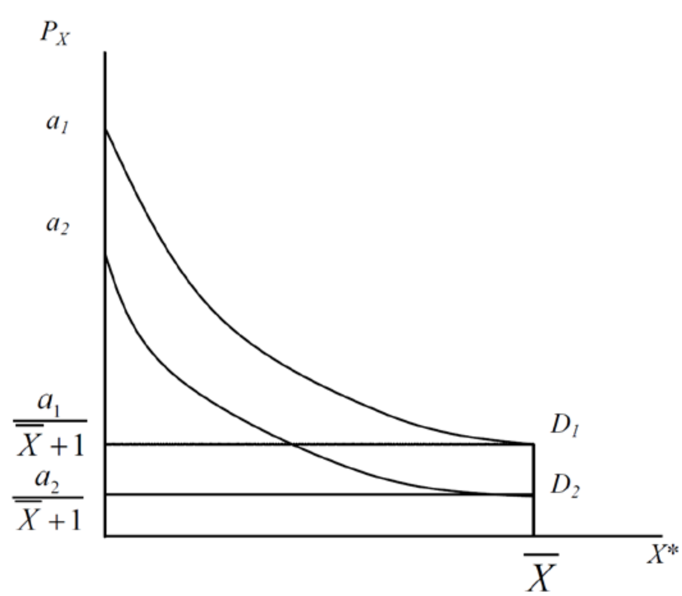

Figure 2: Heterogeneous Willingness-to-pay Customers

[5] If we normalize $\overline{X}$ to be 1, this condition means $m > n$.

From Lemmas 4, 5, and 6, we know the maximum profits achievable when the service provider adopts each of the pricing mechanisms, pure flat fee pricing, pure usage-based pricing, and two-part tariff pricing. It is not hard to show that for all $\overline{X} \geq 0$ and $\overline{Y} \geq 0$, $m[a_2 \log(\overline{X}+1) + b_2 \log(\overline{Y}+1)] + n[a_2 \log(\overline{X}+1) + b_2 \log(\overline{Y}+1)] > m(a_1 - \frac{a_1}{\overline{X}+1} + b_1 - \frac{b_1}{\overline{Y}+1}) + n(a_2 - \frac{a_1}{\overline{X}+1} + b_2 - \frac{b_1}{\overline{Y}+1})$. Therefore, pure flat fee pricing and two-part tariff pricing are strictly preferred to pure usage-based pricing from the service provider's profit maximization point of view.

> **Proposition 1 (Pricing Scheme Selection When Customers Have Heterogeneous Willingness to Pay – Two Types)** *When there are two types of consumers characterized by heterogeneous willingness to pay in the market, flat fee pricing and two-part tariff pricing yield the same profit, which is higher than pure usage-based pricing.*

Note that the conclusion from this subsection is exactly the same as that derived in Subsection 4.1., that is, the flat fee pricing and the two-part tariff always yield the same profit, and dominate usage-based pricing. The intuition behind this is that if the information service providers have sufficient capacity and negligible marginal and monitoring costs, they have the incentive to set the prices at levels that would encourage the customers to consume as much as they want, as in the case when all consumers are homogeneous. While the supplier can easily use flat fee pricing to extract all consumer surplus when all consumers are homogeneous, it can only successfully extract the consumer surplus of the low-end consumers and leave a large surplus to its high-end consumers if it is in the firm's interest to serve both segments. The same is true for the two-part tariff. No matter what unit usage price the information service provider sets for the service, the best subscription fee it can charge the consumers is the consumer surplus of the low-end consumers. Any subscription fee more than this will cause the information service provider to lose all of the low-end consumers. As a result, the high-end consumers will still enjoy a large surplus.

Another interesting thing from the analysis that is different from the case when all consumers are homogeneous is that if we compare the cases of pure usage-based pricing and two-part tariff pricing, we can clearly see that with pure usage-based pricing, sometimes it is in the firm's interest to set the unit usage prices at a higher level (depending on the relative size of the market segments) so that only the high-end consumers will fully utilize the service to their maximum levels and the low-end consumers will consume less. When this is the case, the revenue collected from the service usage is less, since the unit usage price is set at a lower level for the two-part tariff, but because the information service provider can charge more subscription fees from both markets segments, this revenue loss can be well compensated. Note also that while these results are established under one or two segments of customers, they could be generalized to a continuous type of customers.

> **Proposition 2 (Pricing Scheme Selection When Customers Have Heterogeneous Willingness to Pay – Multiple Types)** *When consumers are characterized by heterogeneous willingness to pay in the market, flat fee pricing and two-part tariff pricing yield the same profit, which is higher than pure usage-based pricing.*
> **Proof**: See the Appendix.

4.2.2. Heterogeneous customers: the high-demand customers and the low-demand customers

In this subsection, we consider how the heterogeneous maximum consumption level might affect a firm's pricing choice. Again, we assume two types of customers, the high-demand customers (type 1) with maximum consumption level at $\overline{X_1}$ and $\overline{Y_1}$ and the low-demand customers (type 2) with maximum consumption level at $\overline{X_2}$ and $\overline{Y_2}$, where $\overline{X_1} > \overline{X_2}$ and $\overline{Y_1} > \overline{Y_2}$. As before, there are *m* type 1 customers and *n* type 2 customers with $a_1 = a_2 = a$ and $b_1 = b_2 = b$.

The optimal price(s) and maximum profit under each scheme are characterized as follows:

Lemma 7: If the service provider uses the pure flat fee, the price charged will be $P = a\log\left(\overline{X}_2 + 1\right) + b\log\left(\overline{Y}_2 + 1\right)$ (for the peak hour problem, it is the area below curve *D* and left of $\overline{X}_2$ in Figure 3), and the maximum profit achievable will be $(m+n)[a\log\left(\overline{X}_2 + 1\right) + b\log\left(\overline{Y}_2 + 1\right)]$.
Proof: See the Appendix.

Lemma 8: If the service provider uses pure usage-based pricing, when $n\overline{X}_2 \geq m$, the optimal price in the peak hours is $P_X = \frac{a}{\overline{X}_2+1}$ (see Figure 3); when $n\overline{Y}_2 \geq m$, the optimal non-peak hour price is $P_Y = \frac{b}{\overline{Y}_2+1}$. The maximum profit is $(m+n)\left(\frac{a\overline{X}_2}{\overline{X}_2+1} + \frac{b\overline{Y}_2}{\overline{Y}_2+1}\right)$; otherwise, the optimal prices are given by $P_X = \frac{a}{\overline{X}_1+1}$ (see Figure 3) and $P_Y = \frac{b}{\overline{Y}_1+1}$ with profit: $m\left(\frac{a\overline{X}_1}{\overline{X}_1+1} + \frac{b\overline{Y}_1}{\overline{Y}_1+1}\right) + n\left(\frac{a\overline{X}_2}{\overline{X}_1+1} + \frac{b\overline{Y}_2}{\overline{Y}_1+1}\right)$.
Proof: See the Appendix.

Lemma 9: If the service provider uses two-part tariff pricing, the optimal P_X and P_Y will be $P_X = \dfrac{a}{\overline{X}_1 + 1}$ and $P_Y = \dfrac{b}{\overline{Y}_1 + 1}$ respectively, and the subscription fee: $P = a\log\left(\overline{X}_2 + 1\right) + b\log\left(\overline{Y}_2 + 1\right) - \left(\dfrac{a\overline{X}_2}{\overline{X}_1 + 1} + \dfrac{b\overline{Y}_2}{\overline{Y}_1 + 1}\right)$ (for the peak hour problem, it is the area below curve *D*, above $\frac{a}{\overline{X}_1+1}$, and left of $\overline{X}_2$ in Figure 3). Therefore, the maximum profit achievable by the service provider is $m\left(a\dfrac{\overline{X}_1 - \overline{X}_2}{\overline{X}_1 + 1} + b\dfrac{\overline{Y}_1 - \overline{Y}_2}{\overline{Y}_1 + 1}\right) + (m+n)(a\log(\overline{X}_2 + 1) + b\log(\overline{Y}_2 + 1))$, which is greater than what can be achieved with either flat fee pricing or usage-based pricing.
Proof: See the Appendix.

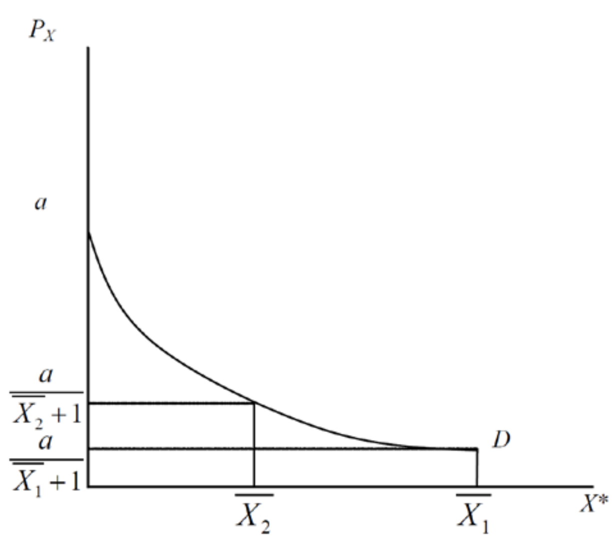

Figure 3: Heterogeneous Maximum-consumption-level Customers

Proposition 3 (Pricing Scheme Selection When Customers Have Heterogeneous Maximum Consumption Levels) *When there are two types of consumers characterized by heterogeneous maximum consumption levels, a two-part tariff always dominates flat fee pricing and usage-based pricing.*

While Subsection 4.1. and Proposition 1 show that when all consumers are homogeneous or when the consumers are characterized by heterogeneous willingness to pay, flat fee pricing and two-part tariff pricing are both optimal pricing schemes, Proposition 3 shows that when consumers are characterized by heterogeneous maximum consumption levels, the two-part tariff is the only optimal pricing scheme. This result is interesting. It identifies the condition under which a two-part tariff is the only optimal pricing scheme even when the marginal cost is negligible. This is an extension to the traditional nonlinear pricing literature as the optimality of the two-part tariff in the traditional nonlinear pricing literature is based on the assumption of relatively large marginal cost. The intuition behind Proposition 3 is that when the heterogeneity is characterized by the difference in maximum consumption levels, the two-part tariff is optimal due to the additional flexibility to address the consumption differences between the consumer groups. In addition to the consumer surplus of the low-demand consumers that can be captured by pure flat fee pricing, the two-part tariff can do better by capturing some more surplus from the high-demand consumers when the consumers are characterized by heterogeneous maximum consumption levels, while this is not true when the consumers are characterized by heterogeneous willingness to pay.

Note also that similar to the case when the consumers are characterized by heterogeneous willingness to pay, with the pure usage-based pricing, the firm may set the unit usage prices at a higher level (also depending on the relative size of the market segments). However, now only the low-demand consumers will fully utilize the service to their maximum levels, while the high-demand consumers will consume less than their maximum consumption levels, contrary to the case when the consumers are characterized by heterogeneous willingness to pay. Again, while the revenue collected from the service usage is less for the two-part tariff in this case, this revenue loss can be compensated for by the flexibility of subscription fees. In the absence of this flexibility, pure flat fee pricing is less desirable than two-part tariff pricing, while pure usage-based pricing is the least attractive for the information service provider to adopt.

5. Model Extension—Marginal Cost and Monitoring Cost

In the previous analyses, we assume that the marginal cost (denoted by *c*) and the monitoring cost (denoted by *t*) are both zero. However, while there is no doubt that the marginal cost and the monitoring cost are both dramatically lowered by advanced information technologies, they may still remain positive in some cases. In this section, we relax this assumption and examine how positive (but small) marginal cost and monitoring cost affect the optimal pricing scheme. Generally speaking, positive marginal cost is expected to make flat fee pricing less attractive and favor two-part tariff pricing and usage-based pricing, while positive monitoring cost tends to make two-part tariff pricing or usage-based pricing less desirable than flat fee pricing since there is no need to incur monitoring expenses in flat fee pricing. The optimal pricing scheme, thus, depends on the tradeoff between these two costs. However, our analysis shows that in the cases where customers are homogeneous or are characterized by heterogeneous willingness to pay, the optimal scheme is not sensitive to these two costs when $c + t$ is below a certain threshold value. Holding *c* constant, reducing monitoring cost *t* does not make two-part tariff pricing or usage-based pricing a better choice than flat fee pricing; on the other hand, holding *t* constant, increasing marginal cost *c* does not make flat fee pricing less attractive than two-part tariff or usage-based pricing, as long as $c + t$ is below a certain value.

As in the previous sections, we analyze the peak hour problem first. We note that the joint problem of peak and non-peak hours can be solved in the same manner.

With positive marginal cost and monitoring cost, the profit from each customer (denoted by π) for the firm under each pricing scheme is given by:

Under flat fee pricing: $\pi = P - c\bar{X}$, and to maximize the profit, P will be set at $a\log(\bar{X}+1)$, with profit achievable: $a\log(\bar{X}+1) - c\bar{X}$.

Under usage-based pricing: $\pi = (P_X - c - t)X(P_X)$, where $X(P_X)$ is the demand function characterized by $X(P_X) = \frac{a}{P_X} - 1$ from the first order condition in the customer's optimization problem. The profit-maximizing per-use price can be shown to be: $P_X{*} = \max\{\frac{a}{\bar{X}+1}, \sqrt{a(c+t)}\}$ from the first order condition $\frac{\partial \pi}{\partial P} = 0$, and the maximum profit can be shown to be $(P_X{*} - c - t)X(P_X{*}) = X(P_X{*}) \cdot P_X{*} - X(P_X{*}) \cdot (c+t)$.

Under two-part tariff pricing: $\pi = (P_X - c - t)X(P_X) + P$, again $X(P_X)$ is the demand function characterized by $X(P_X) = \frac{a}{P_X} - 1$ from the first order condition in the customer's optimization problem. According to the first order condition $\frac{\partial \pi}{\partial P} = 0$, we can derive the profit-maximizing per-use price, $P_X{*} = \max\{\frac{a}{\bar{X}+1}, \sqrt{a(c+t)}\}$, and *P*, the subscription fee, will be set at $a\log(X(P_X{*})+1) - X(P_X{*}) \cdot P_X{*}$, to fully extract consumer surplus. The maximum profit is, thus, equal to $a\log(X(P_X{*})+1) - X(P_X{*}) \cdot (c+t)$.

While traditional nonlinear pricing theory has suggested that the optimal pricing strategy for a monopolist is strictly based on usage, and many researchers strongly advocate the optimality of two-part tariff pricing when there is a relatively high marginal cost of production, in this paper we are most interested in the cases when both the marginal cost and the monitoring cost are dramatically lowered with the advance of information technology. This maps to the case when $\frac{a}{\bar{X}+1} \geq \sqrt{a(c+t)}$ (or $\frac{a}{(\bar{X}+1)^2} \geq (c+t)$), when both the marginal cost and the monitoring cost are at a low level. In fact, when $\frac{a}{\bar{X}+1} \geq \sqrt{a(c+t)}$ (or $\frac{a}{(\bar{X}+1)^2} \geq (c+t)$), $P_X^* = \frac{a}{\bar{X}+1}$. The maximum profit achievable with flat fee pricing is equal to $a\log(\bar{X}+1) - c\bar{X}$; the maximum profit achievable with usage-based pricing is equal to $(P_X^* - c - t)X(P_X^*) = \left(\frac{a}{\bar{X}+1} - c - t\right)\bar{X} = \frac{a\bar{X}}{\bar{X}+1} - c\bar{X} - t\bar{X}$; while the maximum profit achievable with two-part tariff pricing is equal to $alog(X(P_X^*)+1) - X(P_X^*)(c+t) = alog(\bar{X}+1) - \bar{X}(c+t) = alog(\bar{X}+1) - c\bar{X} - t\bar{X}$. Note that because log($\bar{X}$ +1) > (1 - $\frac{1}{\bar{X}+1}$) and we have assumed $\frac{a}{(\bar{X}+1)^2} \geq (c+t)$, it is not hard to see that $a\log(\bar{X}+1) - c\bar{X} \geq a\log(\bar{X}+1) - c\bar{X} - t\bar{X} > \frac{a\bar{X}}{\bar{X}+1} - c\bar{X} - t\bar{X} > \frac{a\bar{X}}{(\bar{X}+1)^2} - c\bar{X} - t\bar{X} \geq 0$.

From our analysis above, we can clearly see that when $(c+t) \leq \frac{a}{(\bar{X}+1)^2}$, flat fee pricing always dominates two-part tariff pricing and usage-based pricing, no matter how large or how small the monitoring cost is (as long as it is positive). When the monitoring cost, *t*, goes down to zero, two-part tariff pricing generates the same profit as flat fee pricing. Also, as long as $(c+t) \leq \frac{a}{(\bar{X}+1)^2}$ and the monitoring cost *t* is positive, increasing marginal cost *c* does not make either usage-based pricing or two-part tariff pricing a better choice than flat fee pricing. Similarly, we can show that for the non-peak hours, when $(c+t) \leq \frac{b}{(\bar{Y}+1)^2}$, flat fee pricing always dominates two-part tariff pricing and usage-based pricing no matter how large or how small the monitoring cost is (as long as it is positive), and increasing marginal cost will not change this result either.

Proposition 4 (Pricing Scheme Selection When the Total of Marginal and Monitoring Costs Are Low) *In the cases where customers are homogeneous or are characterized by heterogeneous willingness to pay, when the total of the marginal cost and the monitoring cost is at a sufficiently low level, flat fee pricing dominates two-part tariff pricing and usage-based pricing.*

The intuition behind Proposition 4 is similar to the cases of Subsection 4.1. and Proposition 1. Flat fee pricing and two-part tariff pricing can both yield the same *revenue,* and usage-based pricing is strictly dominated in terms of revenue, but because there are positive (but small) marginal cost and monitoring cost to consider now, flat fee pricing can do better in terms of *profit*. While all three pricing schemes are affected by the positive marginal cost, flat fee pricing is free from the burden of positive monitoring cost, as there is essentially no need to monitor customers' consumption for flat fee pricing. And for this reason, the optimal scheme becomes insensitive to these two costs when their sum is low. Holding monitoring cost constant, increasing marginal cost does not make flat fee pricing a worse choice than two-part tariff pricing or usage-based pricing, because it will have the same impact on all three pricing schemes. On the other hand, holding marginal cost constant, reducing monitoring cost does not make two-part tariff pricing or usage-based pricing better than flat fee pricing as long as the monitoring cost is still positive. This is because the monitoring cost will inevitably impact the revenue from two-part tariff pricing and usage-based pricing anyway.

This result is interesting because it suggests that as the marginal cost is lowered with improving information technology (but not necessarily to zero), flat fee pricing becomes the optimal scheme, even though the monitoring cost may go down. A direct implication of this proposition is that flat fee pricing will become more attractive for information service providers. Also this result will be robust as long as the sum of the marginal cost and the monitoring cost is low. However, when the monitoring cost becomes negligible, two-part tariff pricing will become as attractive as flat fee pricing.

6. Discussion and Conclusion

The main objective of this paper is to help information service providers determine the most profitable pricing scheme to offer their customers and the optimal prices to charge them for subscription and usage. How information services should be priced has emerged as an important question as advances in information technology have continued to reduce marginal production and monitoring costs. However, prior research has not resolved when the information service providers should adopt flat fee pricing and when they should adopt usage-based pricing with or without a subscription fee.

We find that when both marginal cost and monitoring cost are negligible for a monopolist provider with homogeneous customers, pure usage-based pricing is strictly dominated by the flat fee and two-part tariff pricing schemes, with the latter two always achieving the same profit level. The same result holds even when customers have heterogeneous marginal willingness to pay, which corresponds to different downward sloping demand curves. The intuition driving this result is that a monopolist information service provider with sufficient capacity can use flat fee pricing to extract the maximum consumer surplus possible. In the case of heterogeneous marginal willingness to pay, flat fee pricing extracts all the surplus of low-end consumers, leaving a surplus only for high-end customers if it is in the firm's interest to serve both segments. The same is true for two-part tariff pricing, but pure usage based pricing is unable to extract all surplus from the low-end customers.

These results explain why many monopoly information service providers charge flat fees for their services. For example, in many regions, there is just one cable TV provider enjoying monopoly power. Most, if not all, cable TV companies use flat monthly fees to extract consumer surplus. Some pay-per-view movie options are offered with two-part tariff pricing, as the customers must subscribe to some kind of cable TV plan before they can buy the on-demand movies. Gogo Inflight Internet also uses flat fee pricing based on the duration of a flight for its in-flight Internet connection services. As the customers essentially have no other Internet connection choice while they are in the air, Gogo Inflight Internet has successfully created a perfect monopoly environment, and its flat fee pricing strategy is also consistent with our results.

When customers are characterized by heterogeneous maximum consumption levels, two-part tariff pricing is more profitable than flat fee pricing due to the additional flexibility to address the consumption differences between the consumer groups. Both continue to dominate pure usage-based pricing. This result is not true when the consumers are characterized simply by heterogeneous willingness to pay. It also extends the traditional nonlinear pricing literature on the optimality of two-part tariff pricing to the case when the marginal cost is negligible. Cruise ship companies employ usage rates with or without a customer activation fee for onboard Internet access. Based on our analyses, we predict that these practices will evolve so that all cruise ship companies charge an activation fee: pure usage-based pricing will permit their customers to obtain the available consumer surplus.

Our results on the optimality of flat fee pricing extends also to the case when we have positive marginal cost and monitoring cost, as long as the total of the marginal cost and the monitoring cost is below a threshold value. Flat fee pricing is preferred because it is free from customer consumption monitoring costs. MySpace, Facebook, and Twitter are all effectively monopolists in their differentiated market segments within the broad social networking space. These sites have decided to attract traffic by offering their services to the general public for free. They adopted the advertising-supported business models early in the development of their business strategies. When they decide to charge their users for their services in the future once there are enough users with high termination or switching costs, we predict they will adopt flat pricing rather than usage-based pricing. As technology evolves to make the monitoring cost negligible, two-part tariff pricing may become more attractive.

We do not present mathematical analyses for a competitive market structure in this paper, and so we prefer not to make claims that go beyond the insights generated by our modeling and analyses. We conjecture, however, that some companies will adopt pure usage-based pricing and leave some consumer surplus to the customers in order to attract more customers, depending on the nature of competition in the industry. From the customers' point of view, pure usage-based pricing is attractive not only because it results in higher consumer surplus but also because it imposes less commitment or lock-in and more freedom to walk away whenever they want. This may explain why in many competitive industries, companies are adopting pure usage-based pricing, even though flat rate and two-part tariff pricing usually enable companies to extract more consumer surplus. For example, Google has employed flat rate pricing for its SaaS services. Google Apps is free for the Basic Edition, but the flat price is $50 per year per person for the Premier Edition. In contrast, Amazon has chosen to charge just a usage rate for its utility computing services (Simple Storage Service, S3, and Elastic Compute Cloud, EC2) to attract more customers concerned about lock-in. Similarly, E*Trade charges trade commissions based solely on the number of trades that its customers place.

Our study suggests several directions for future research. Our analysis of three simple but popular pricing schemes is a first step toward understanding what are the most profitable pricing mechanisms for information services. To survive in a challenging business environment, information service providers must be more creative in designing their pricing strategies. For example, the service provider may wish to structure a pricing scheme that can redirect consumption from peak to non-peak hours when there are capacity constraints. A rigorous analysis of a duopoly or other competitive market structure may reveal strategic factors that influence market share and equilibrium pricing strategies. Yet another interesting direction to pursue is to study how providers can offer different quality levels and prices for their information services with a menu of options from which their customers can choose their preferred quality of services. Alternatively, future research may explore how providers could use a bundling strategy for different information services.

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References:

Armstrong, M. (1996) “Multiproduct Nonlinear Pricing,” *Econometrica* (64) 1, pp. 51–75.

Armstrong, M. and J. Vickers (2001) “Competitive price discrimination,” *Rand J. Econom.* (32) 4, pp. 579–605.

Bakos, Y. and E. Brynjolfsson (1999) “Bundling Information Goods: Pricing, Profits and Efficiency,” *Management Science* (45) 12, pp. 1613-1630.

Calem, P. S. and D. F. Spulber (1984) “Multiproduct Two-part Tariffs,” *Internat. J. Indust. Organ.* (2), pp. 339–357.

Choi, S., O. Dale, and A. B. Whinston (1997) *The Economics of Electronic Commerce.* Macmillan Technical Publishing, Indianapolis, Indiana.

Chuang, C. I. and M. A. Sirbu (1999) “Optimal Bundling Strategy for Digital Information Goods: Network Delivery of Articles and Subscriptions,” *Information Economics and Policy* (11) 2, pp. 147-176.

Curle, D. (1998) “There is no value if it’s not relevant,” *Information Today* (15) 8.

Essegaier, S., S. Gupta, and Z. J. Zhang (2002) “Pricing Access Services,” *Marketing Science* (21) 2, pp. 139-159.

Fishburn, P.C., A. M. Odlyzko, and R. C. Siders (1997) “Fixed fee versus unit pricing for information goods: competition, equilibria, and price wars,” *Proceedings of the Conference on Internet Publishing and Beyond: Economics of Digital Information and Intellectual Property.* Cambridge MA.

Fudenberg, D. and J. Tirole (1993) *Game Theory.* The Massachusetts Institute of Technology Press, Cambridge, MA.

Hayes, B. (1987) “Competition and two-part tariffs,” *J. Bus.* (60) 1, pp. 41-54.

Jain, D., E. Muller, and N. Vilcassim (1999) “Pricing patterns of Cellular Phones and Phonecalls: A Segment-Level Analysis,” *Management Science* (45) 2, pp. 131-41.

Maskin, E. and J. Riley (1984) “Monopoly with incomplete information”. *RAND J. Econom.* (15), pp. 171–196.

Masuda, Y. and S. Whang (2006) “On the Optimality of Fixed-up-to Tariff for Telecommunications Services,” *Information Systems Research* (17) 3, pp. 247-253.

Metcalfe, R. (1997) “Pollinate lets you rent the software you need for just the right amount of time,” *Infoworld* (June 9).

Oi, W. Y. (1971) “A Disneyland dilemma: Two-part tariffs for a Mickey mouse monopoly,” *Quart. J. Econom*. (85) 1, pp. 77-96.

PCS Week (1997) “Market worries as PCS carriers experiment with pricing,” (8) 6.

Pindyck, R and D. Rubinfeld (1998) *Microeconomics*. Prentice-Hall, Inc., New Jersey.

Rochet, J. and L. A. Stole (2002) “Nonlinear pricing with random participation constraints,” *Rev. Econom. Stud.* (69) 1, pp. 277-311.

Schmalensee, R. (1981) “Monopolistic two-part pricing arrangements,” *Bell J. Econom.* (12) 2, pp. 445–466.

Stole, L. A. (1995) “Nonlinear pricing and oligopoly,” *J. Econom. Management Strategy* (4) 4, pp. 529–562.

Sundararajan, A. (2004) “Nonlinear Pricing of Information Goods,” *Management Science* (50) 12, pp. 1660-1673.

Varian, H. R. (2000) “Buying, Sharing and Renting Information Goods,” *Journal of Industrial Economics* (48) 4, pp. 473-488.

Wilson, R. (1993) *Nonlinear Pricing*. Oxford University Press, New York.

Wu, S. (2007) “Optimal Infrastructure Design and Expansion of Broadband Wireless Access Networks,” *European Journal of Operational Research* (178) 1, pp. 322-329.

Wu, S. and P. Chen (2008) “Versioning and Piracy Control for Digital Information Goods,” *Operations Research* (56) 1, pp. 157-172.

Wu, S., L. Hitt, P. Chen, and G. Anandalingam (2008) “Customized Bundle Pricing for Information Goods: A Nonlinear Mixed Integer Programming Approach,” *Management Science* (54) 3, pp. 608-622.

Appendix

Proof of Lemma 1:
If the service provider uses the pure flat fee pricing by setting $P_X = 0$, $P_Y = 0$, and $P > 0$:

It is clear that given this pricing plan, the consumers will fully utilize the service by choosing the consumption level $X = \overline{X}$ and $Y = \overline{Y}$ with the maximum utility the consumers can get $a\log(\overline{X}+1) + b\log(\overline{Y}+1)$. It is then obvious that the maximum flat fee the service provider can charge is $a\log(\overline{X}+1) + b\log(\overline{Y}+1)$, with maximum profit: $\sum_i [a\log(\overline{X}+1) + b\log(\overline{Y}+1)]$.

Proof of Lemma 2:
If the service provider uses the pure usage-based pricing by setting $P_X > 0$, $P_Y > 0$, and $P = 0$:

Taking first-order conditions for optimality of consumer's optimization problem yield:

$$\frac{a}{X^*+1} = P_X \;\; => \;\; X^* = \frac{a}{P_X} - 1$$

$$\frac{b}{Y^*+1} = P_Y \;\; => \;\; Y^* = \frac{b}{P_Y} - 1$$

Supplier's Optimization Problem becomes:

$$\underset{P_X, P_Y}{\mathrm{Max}} \sum_i (P_X X^* + P_Y Y^*) = \underset{P_X, P_Y}{\mathrm{Max}} \sum_i (a - P_X + b - P_Y)$$

It is clear that to maximize the function above, the supplier will have to minimize P_X and P_Y. From the first order conditions, we know that as P_X and P_Y decrease, X^* and Y^* will increase. However, since X and Y are bounded, X^* and Y^* will eventually become $\overline{X}$ and $\overline{Y}$. In other words, the best P_X and P_Y will be $P_X = \frac{a}{\overline{X}+1}$ and $P_Y = \frac{b}{\overline{Y}+1}$, with maximum profit: $\sum_i (a - \frac{a}{\overline{X}+1} + b - \frac{b}{\overline{Y}+1}) = \sum_i [a(1 - \frac{1}{\overline{X}+1}) + b(1 - \frac{1}{\overline{Y}+1})]$.

Proof of Lemma 3:
If the service provider uses the two-part tariff pricing by setting $P_X > 0$, $P_Y > 0$, and $P > 0$:

Again, the first-order conditions for optimality of consumer's optimization problem are:

$$\frac{a}{X^*+1} = P_X \;\; => \;\; X^* = \frac{a}{P_X} - 1$$

$$\frac{b}{Y^*+1} = P_Y \;\; => \;\; Y^* = \frac{b}{P_Y} - 1$$

Supplier's Optimization Problem becomes:

$$\underset{P_X, P_Y, P}{\mathrm{Max}} \sum_i (P_X X^* + P_Y Y^* + P) = \underset{P_X, P_Y, P}{\mathrm{Max}} \sum_i (a - P_X + b - P_Y + P)$$

Likewise, it is clear that to maximize the function above, the supplier will have to minimize P_X and P_Y. From the first order conditions, we know that as P_X and P_Y decrease, X^* and Y^* will increase. Nevertheless, since X and Y are bounded, X^* and Y^* will eventually become $\overline{X}$ and $\overline{Y}$. In other words, the best P_X and P_Y will be $P_X = \frac{a}{\overline{X}+1}$ and $P_Y = \frac{b}{\overline{Y}+1}$. The maximum subscription fee P the supplier can charge is then the difference between the maximum utility the consumers can get, $a\log($

$\overline{X}$ +1) + *b* log($\overline{Y}$ +1), and the payment for their usage, (*a* - $\frac{a}{\overline{X}+1}$ + *b* - $\frac{b}{\overline{Y}+1}$). Therefore, the maximum profit achievable by the service provider is $\sum_i$ [*a* log($\overline{X}$ +1) + *b* log($\overline{Y}$ +1)], the same as in the case when the service provider adopts the flat fee pricing mechanism.

Proof of Lemma 4:
It is clear that given $P_X = 0$, $P_Y = 0$, and $P > 0$, if a consumer chooses to join the program, she will fully utilize the service by choosing the consumption level $X_1 = \overline{X}$, $Y_1 = \overline{Y}$ or $X_2 = \overline{X}$, $Y_2 = \overline{Y}$. Given this, it is obvious that the service provider can charge each high-end consumer no more than $a_1 \log\left(\overline{X}+1\right) + b_1 \log\left(\overline{Y}+1\right)$, and each low-end consumer no more than $a_2 \log\left(\overline{X}+1\right) + b_2 \log\left(\overline{Y}+1\right)$. It can be easily shown that if we assume $a_1 < \frac{m+n}{m} a_2$ and $b_1 < \frac{m+n}{m} b_2$ (these correspond to our assumption that it is more profitable for the firm to serve both segments), the service provider will charge $a_2 \log\left(\overline{X}+1\right) + b_2 \log\left(\overline{Y}+1\right)$ and serve both high-end and low-end consumers with the maximum profit achievable $(m+n)\left[a_2 \log\left(\overline{X}+1\right) + b_2 \log\left(\overline{Y}+1\right)\right]$.

Proof of Lemma 5:
When $P_X > 0$, $P_Y > 0$, and $P = 0$, the first-order conditions for optimality of high-end/low-end consumer's optimization problem yield:

$$\frac{a_1}{X_1*+1} = P_X \Rightarrow X_1* = \frac{a_1}{P_X} - 1 \tag{20}$$

$$\frac{b_1}{Y_1*+1} = P_Y \Rightarrow Y_1* = \frac{b_1}{P_Y} - 1 \tag{21}$$

$$\frac{a_2}{X_2*+1} = P_X \Rightarrow X_2* = \frac{a_2}{P_X} - 1 \tag{22}$$

$$\frac{b_2}{Y_2*+1} = P_Y \Rightarrow Y_2* = \frac{b_2}{P_Y} - 1 \tag{23}$$

The Supplier's Optimization Problem becomes:

$$\underset{P_X, P_Y}{\text{Max}}\ m(P_X X_1* + P_Y Y_1*) + n(P_X X_2* + P_Y Y_2*) = \underset{P_X, P_Y}{\text{Max}}\ m(a_1 - P_X + b_1 - P_Y) + n(a_2 - P_X + b_2 - P_Y)$$

To maximize the function above, the supplier will have to minimize P_X and P_Y. From (20) - (23), we know that as P_X and P_Y decrease, X_1*, X_2*, Y_1* and Y_2* will increase. But since X_1, X_2, Y_1 and Y_2 are bounded (constraints (15) and (16)), X_1*, X_2*, Y_1* and Y_2* cannot exceed $\overline{X}$ and $\overline{Y}$ respectively, and this suggests that as price goes down further, no increase in demand can be expected. To derive the optimal prices, we consider the peak hour problem first. The peak hour demand curves of the high-end and low-end consumers (constraints (20) and (22)) are shown in Figure 4 (D_1 and D_2).

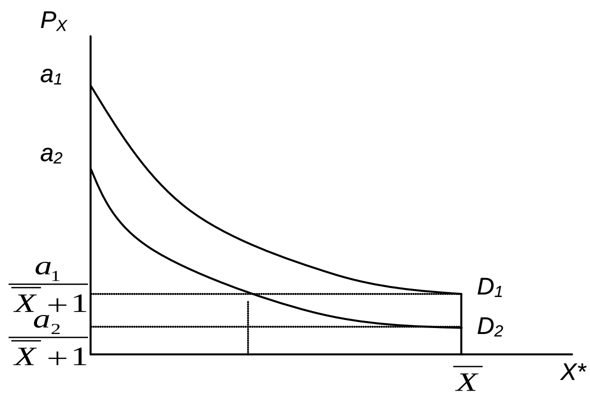

Figure 4: The Peak Hour Demand Curves of the High-end and Low-end Consumers

The supplier's optimization problem is:

$$\underset{P_X}{\text{Max}}\ m(P_X X_1^*) + n(P_X X_2^*) = \underset{P_X}{\text{Max}}\ m(a_1 - P_X) + n(a_2 - P_X)\,.$$

To maximize this function, the supplier will have to minimize P_X and therefore the best price P_X cannot be larger than $\frac{a_1}{\bar{X}+1}$. On the other hand, if the supplier sets the price below $\frac{a_2}{\bar{X}+1}$, the profit is not optimal since X_1^* and X_2^* cannot exceed $\bar{X}$ and user demand will not increase as the price decreases. Hence, the best price P_X must be somewhere between $\frac{a_1}{\bar{X}+1}$ and $\frac{a_2}{\bar{X}+1}$. When the price is in this interval, the demand of the high-end consumer is fixed at $\bar{X}$ while the demand of the low-end consumer keeps on increasing as the price goes down. Thus, we have:

$$\underset{P_X}{\text{Max}}\ m(P_X X_1^*) + n(P_X X_2^*) = \underset{P_X}{\text{Max}}\ m(P_X \bar{X}) + n(a_2 - P_X) = \underset{P_X}{\text{Max}}\ n a_2 + (m\bar{X} - n)P_X\,.$$

When $m\bar{X} > n$, the best price P_X in this interval is therefore $\frac{a_1}{\bar{X}+1}$, otherwise, $P_X = \frac{a_2}{\bar{X}+1}$. Similar analysis can be done on the non-peak hour problem and we can get the best price $P_Y = \frac{b_1}{\bar{Y}+1}$ when $m\bar{Y} > n$, or $P_Y = \frac{b_2}{\bar{Y}+1}$ otherwise.

Proof of Lemma 6:

When $P_X > 0$, $P_Y > 0$, and $P > 0$, the first-order conditions for the high-end/low-end consumer's optimization problem yield Equations (20)-(23).

Likewise, we use the divide-and-conquer technique to do the analysis. As before, we consider only the peak hour problem here. The joint problem with non-peak hours can be solved in a similar way. Equations (20) and (22) are the peak hour demand curves of the high-end and low-end consumers (D_1 and D_2 in Figure 5).

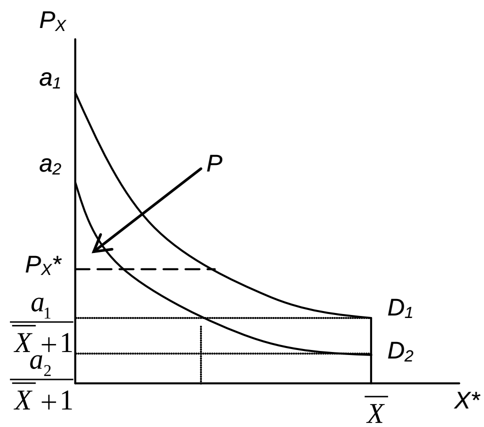

Figure 5: The Best Subscription Fee is Equal to the Consumer Surplus of the Low-end Consumers

First, we make the following observation: no matter what unit usage price P_X the supplier sets for the service, the best subscription fee P it can charge the consumers is the consumer surplus of the low-end consumers (the triangle area under D_2 and above P_X).[6] Any subscription fee more than this will let the supplier lose all of the low-end consumers.

Note that given these demand functions, if the supplier set the unit usage price $P_X \geq \frac{a_1}{\overline{X}+1}$, the supplier's optimization problem will be:

$$\underset{P_X,P}{\mathrm{Max}}\, m(P_X X_1{*}) + n(P_X X_2{*}) + (m+n)P = \underset{P_X}{\mathrm{Max}}\, m(a_1 - P_X) + n(a_2 - P_X) + (m+n)\int_0^{\frac{a_2}{P_X}-1}\left(\frac{a_2}{X_2+1} - P_X\right)\mathrm{d}X_2$$

$$= \underset{P_X}{\mathrm{Max}}\ \ m(a_1 - a_2) + (m+n)a_2 \log(\frac{a_2}{P_X})$$

To maximize this function the supplier will have to minimize P_X and therefore the best price P_X in this interval is $\frac{a_1}{\overline{X}+1}$ with the maximum profit achievable $m(a_1 - a_2) + (m+n)a_2 \log\frac{a_2}{a_1}(\overline{X}+1)$.

Second, if the supplier sets the unit usage price $\frac{a_2}{\overline{X}+1} \leq P_X \leq \frac{a_1}{\overline{X}+1}$, the supplier's optimization problem will be:

$$\underset{P_X,P}{\mathrm{Max}}\, m(P_X X_1{*}) + n(P_X X_2{*}) + (m+n)P = \underset{P_X}{\mathrm{Max}}\, m(P_X \overline{X}) + n(a_2 - P_X) + (m+n)\int_0^{\frac{a_2}{P_X}-1}\left(\frac{a_2}{X_2+1} - P_X\right)\mathrm{d}X_2$$

$$= \underset{P_X}{\mathrm{Max}}\ \ m(\overline{X}+1)P_X - ma_2 + (m+n)a_2 \log(\frac{a_2}{P_X})$$

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[6] We assume that it is more profitable for the firm to serve both market segments, $a_1 < \frac{m+n}{m} a_2$ and $b_1 < \frac{m+n}{m} b_2$.

The best price P_X in this interval is $\frac{a_2}{\overline{X}+1}$ with the maximum profit achievable $(m+n)a_2\log(\overline{X}+1)$. Note that this profit is larger than $m(a_1-a_2)+(m+n)a_2\log\frac{a_2}{a_1}(\overline{X}+1)$ (the profit we can get from another boundary point $\frac{a_1}{\overline{X}+1}$).

Third, if the supplier sets the unit usage price $0 \le P_X \le \frac{a_2}{\overline{X}+1}$, the supplier's optimization problem will be:

$$\underset{P_X,P}{\mathrm{Max}}\ m(P_X X_1^*)+n(P_X X_2^*)+(m+n)P = \underset{P_X}{\mathrm{Max}}\ m(P_X\overline{X})+n(P_X\overline{X})+(m+n)\int_0^{\overline{X}}\left(\frac{a_2}{X_2+1}-P_X\right)\mathrm{d}X_2$$

$$= \underset{P_X}{\mathrm{Max}}\ (m+n)a_2\log(\overline{X}+1)$$

It is clear that to maximize this function the supplier can set the price anywhere between 0 and $\frac{a_2}{\overline{X}+1}$ with the maximum profit achievable $(m+n)a_2\log(\overline{X}+1)$.

Given the above analysis, we know that the supplier can set the optimal price P_X anywhere between 0 and $\frac{a_2}{\overline{X}+1}$, and P_Y anywhere between 0 and $\frac{b_2}{\overline{Y}+1}$, and subscription fee P equal to the consumer surplus of the low-end consumers, with the maximum profit achievable $(m+n)[a_2\log(\overline{X}+1)+b_2\log(\overline{Y}+1)]$. However, since many consumers see the subscription fee as some kind of entry barrier, the supplier may prefer to lower this entry barrier so that it can attract more consumers. If this is the case, the supplier can set the unit usage prices P_X and P_Y at a higher level $\frac{a_2}{\overline{X}+1}$ and $\frac{b_2}{\overline{Y}+1}$ respectively, and minimize the subscription fee $P = a_2\log(\overline{X}+1)+b_2\log(\overline{Y}+1)-\frac{a_2\overline{X}}{\overline{X}+1}-\frac{b_2\overline{Y}}{\overline{Y}+1}$, still with the maximum profit achievable: $(m+n)[a_2\log(\overline{X}+1)+b_2\log(\overline{Y}+1)]$.[7]

Proof of Proposition 2:

Assume customer *i* has type: a_i and b_i, which follow the uniform distribution between 0 and 1, that is *i*, a_i and b_i are all normalized to be between 0 and 1, ~ U(0,1). Note that with this assumption, we implicitly assume $i = a_i = b_i$ since they are all between 0 and 1 now.

If the service provider uses the flat fee pricing:

Given $P_X = 0$, $P_Y = 0$, and $P > 0$, charged by the firm, we can determine the marginal customer, *M*, who will sign up by $a_M\log(\overline{X}+1)+b_M\log(\overline{Y}+1)=P$, with profit for the firm $(1-M)P$. To maximize the profit, the firm will set $P=\frac{1}{2}[\log(\overline{X}+1)+\log(\overline{Y}+1)]$, with $M=\frac{1}{2}$, i.e. customers with

[7] The same argument holds for the case when all consumers are homogeneous and the firm adopts the two-part tariff pricing as in Lemma 3.

type higher than $\frac{1}{2}$ will join the service. The maximum profit under this scheme is thus $\frac{1}{4}[\log(\bar{X}+1)+\log(\bar{Y}+1)]$.

If the service provider uses the pure usage-based pricing:
As before, the demand function is characterized by $X_i=\frac{a_i}{P_x}-1\le\bar{X}$, that is, when $P_X\ge\frac{a_i}{\bar{X}+1}$, we have $X_i\le\bar{X}$; and when $P_X<\frac{a_i}{\bar{X}+1}$, we have $X_i=\bar{X}$. In addition, given this demand function, a customer with type higher than $P_X(\bar{X}+1)$ will consume $\bar{X}$. Similarly, we also have $Y_i=\frac{b_i}{P_Y}-1\le\bar{Y}$, that is, when $P_Y\ge\frac{b_i}{\bar{Y}+1}$, we have $Y_i\le\bar{Y}$; and when $P_Y<\frac{b_i}{\bar{Y}+1}$, we have $Y_i=\bar{Y}$. In addition, given this demand function, a customer with type higher than $P_Y(\bar{Y}+1)$ will consume $\bar{Y}$.

The firm will choose P_X and P_Y that maximize its profit: $\int_0^{P_X(\bar{X}+1)}X_iP_X\,da+[1-P_X(\bar{X}+1)]\bar{X}P_X+\int_0^{P_Y(\bar{Y}+1)}Y_iP_Y\,db+[1-P_Y(\bar{Y}+1)]\bar{Y}P_Y$. Plugging in $X_i=\frac{a_i}{P_x}-1\le\bar{X}$ and $Y_i=\frac{b_i}{P_Y}-1\le\bar{Y}$, and solving the first order conditions, we can then solve this optimization problem and get $P_X=\frac{\bar{X}}{(\bar{X}+1)^2}$ and $P_Y=\frac{\bar{Y}}{(\bar{Y}+1)^2}$ with profit: $\frac{1}{2}\left[\left(\frac{\bar{X}}{\bar{X}+1}\right)^2+\left(\frac{\bar{Y}}{\bar{Y}+1}\right)^2\right]$, which is smaller than $\frac{1}{4}[\log(\bar{X}+1)+\log(\bar{Y}+1)]$, the profit of the flat fee pricing, as $\frac{1}{4}\log(\bar{X}+1)>\frac{1}{2}\left(\frac{\bar{X}}{\bar{X}+1}\right)^2$ and $\frac{1}{4}\log(\bar{Y}+1)>\frac{1}{2}\left(\frac{\bar{Y}}{\bar{Y}+1}\right)^2$ for all $\bar{X},\bar{Y}>0$.

If the service provider uses the two-part tariff pricing:
The firm will choose P_X, P_Y and P to maximize its profit. Note that given any P_X, P_Y and P, the marginal customer, *M*, who will sign up the service is determined by $a_M\log(X_M+1)+b_M\log(Y_M+1)-X_MP_X-Y_MP_Y-P=0$ and the profit of the service provider is $\int_M^{P_X(\bar{X}+1)}X_iP_X\,da+[1-P_X(\bar{X}+1)]\bar{X}P_X+\int_M^{P_Y(\bar{Y}+1)}Y_iP_Y\,db+[1-P_Y(\bar{Y}+1)]\bar{Y}P_Y+(1-M)P$. To maximize the profit, we can plug in $X_i=\frac{a_i}{P_x}-1\le\bar{X}$, $Y_i=\frac{b_i}{P_Y}-1\le\bar{Y}$, $P=a_M\log(X_M+1)+b_M\log(Y_M+1)-X_MP_X-Y_MP_Y$ and $M=a_M=b_M$, and solve the FOCs. The firm will set $P_X=\frac{1}{2}\frac{1}{(\bar{X}+1)}$ and $P_Y=\frac{1}{2}\frac{1}{(\bar{Y}+1)}$ and $P=\frac{1}{2}\left[\log(\bar{X}+1)+\log(\bar{Y}+1)-\frac{\bar{X}}{(\bar{X}+1)}-\frac{\bar{Y}}{(\bar{Y}+1)}\right]$, with $M=\frac{1}{2}$ and the maximum profit: $\frac{1}{4}[\log(\bar{X}+1)+\log(\bar{Y}+1)]$, which is the same as what can be achieved in the flat fee pricing scheme.

Proof of Lemma 7:
If the service provider uses the pure flat rate pricing by setting $P_X = 0$, $P_Y = 0$, and $P > 0$:

It is clear that given this pricing plan, if a consumer (either high-demand consumer or low-demand consumer) chooses to join the program, she will fully utilize the service by choosing the consumption level $X_1=\overline{X}_1$, $Y_1=\overline{Y}_1$ or $X_2=\overline{X}_2$, $Y_2=\overline{Y}_2$ with the maximum utility receivable $a\log(\overline{X}_1+1)+b\log(\overline{Y}_1+1)$ or $a\log(\overline{X}_2+1)+b\log(\overline{Y}_2+1)$ (for high-demand and low-demand consumer respectively). Then it is obvious that the service provider can charge each high-demand consumer no more than $a\log(\overline{X}_1+1)+b\log(\overline{Y}_1+1)$ and each low-demand consumer no more than $a\log(\overline{X}_2+1)+b\log(\overline{Y}_2+1)$ as the flat rate for the service. Since we assume the service provider could not distinguish high-demand and low-demand consumers and must charge them the same price, the service provider can either charge $a\log(\overline{X}_1+1)+b\log(\overline{Y}_1+1)$ and serve only high-demand consumers or charge $a\log(\overline{X}_2+1)+$

b log($\overline{Y_2}$ +1) and serve both high-demand and low-demand consumers. If we further assume that *m* [*a* log($\overline{X_1}$ +1) + *b* log($\overline{Y_1}$ +1)] < (*m* + *n*) [*a* log($\overline{X_2}$ +1) + *b* log($\overline{Y_2}$ +1)], the best the service provider can do is charge *a* log($\overline{X_2}$ +1) + *b* log($\overline{Y_2}$ +1) and serve both high-demand and low-demand consumers with the maximum profit achievable (*m* + *n*) [*a* log($\overline{X_2}$ +1) + *b* log($\overline{Y_2}$ +1)].

Proof of Lemma 8:

If the service provider uses the pure usage-based pricing by setting $P_X > 0$, $P_Y > 0$, and $P = 0$:

The first-order conditions for optimality of high-demand/low-demand consumer's optimization problem yield:

$$\frac{a}{X_1*+1} = P_X \;\; => \;\; X_1* = \frac{a}{P_X} - 1 \qquad (24)$$

$$\frac{b}{Y_1*+1} = P_Y \;\; => \;\; Y_1* = \frac{b}{P_Y} - 1 \qquad (25)$$

$$\frac{a}{X_2*+1} = P_X \;\; => \;\; X_2* = \frac{a}{P_X} - 1 \qquad (26)$$

$$\frac{b}{Y_2*+1} = P_Y \;\; => \;\; Y_2* = \frac{b}{P_Y} - 1 \qquad (27)$$

The Supplier's Optimization Problem will become:
Max m ($P_X X_1* + P_Y Y_1*$) + n ($P_X X_2* + P_Y Y_2*$)
= Max m (a_1 - P_X + b_1 - P_Y) + n (a_2 - P_X + b_2 - P_Y)

It is clear that to maximize the equation above, the supplier will have to minimize P_X and P_Y. From Equations (24), (25), (26) and (27), we know that as P_X and P_Y decrease, X_1*, X_2*, $Y_1*$and Y_2* will increase. But since X_1, X_2, Y_1 and Y_2 are bounded at $\overline{X_1}$, $\overline{X_2}$, $\overline{Y_1}$ and $\overline{Y_2}$ respectively, the best P_X and P_Y will be $P_X = \frac{a}{\overline{X_2}+1}$ and $P_Y = \frac{b}{\overline{Y_2}+1}$, with maximum profit achievable *m* (*a* - $\frac{a}{\overline{X_2}+1}$ + *b* - $\frac{b}{\overline{Y_2}+1}$) + *n* (*a* - $\frac{a}{\overline{X_2}+1}$ + *b* - $\frac{b}{\overline{Y_2}+1}$), when $n\overline{X_2} \geq m$ and $n\overline{Y_2} \geq m$.

To see why this is true, let's consider only the peak-hour problem first. Equations (24) and (26) are actually the peak-hour demand curves of the high-demand and low-demand consumers. Note that X_1*, X_2* are bounded at $\overline{X_1}$ and $\overline{X_2}$. Now the supplier's optimization problem will be Max m ($P_X X_1*$) + n ($P_X X_2*$) = Max m (a_1 - P_X) + n (a_2 - P_X). It is clear that to maximize this equation, the supplier will have to minimize P_X and therefore the best price P_X cannot be larger than $\frac{a}{\overline{X_2}+1}$. On the other hand, if the supplier sets the price below $\frac{a}{\overline{X_1}+1}$, the profit is not optimal since $X_1*$and X_2* cannot exceed $\overline{X_1}$ and $\overline{X_2}$ and user demand won't increase as the price decreases. Hence, the best price P_X must be somewhere between $\frac{a}{\overline{X_1}+1}$ and $\frac{a}{\overline{X_2}+1}$. When the price is in this interval, the demand of the low-demand consumer is fixed at $\overline{X_2}$ while the demand of the high-demand consumer keeps on increasing as the price goes down. Now the supplier's optimization problem will be Max m ($P_X X_1*$) +

n ($P_X X_2$*) = Max *m* (*a* - P_X) + *n* ($P_X \overline{X}_2$) = Max *ma* + (*n* $\overline{X}_2$ -*m*)P_X. When $n\overline{X}_2 \geq m$, the best price P_X in this interval is therefore $\frac{a}{\overline{\overline{X}}_2 + 1}$. Similar analysis can be done on the non-peak-hour problem and we can get the best price $P_Y = \frac{b}{\overline{\overline{Y}}_2 + 1}$ when $n\overline{Y}_2 \geq m$.

Therefore, if the service provider uses the pure usage-based pricing, when $n\overline{X}_2 \geq m$, the optimal price in the peak hours is $P_X = \frac{a}{\overline{\overline{X}}_2+1}$; when $n\overline{Y}_2 \geq m$, the optimal non-peak hour price is $P_Y = \frac{b}{\overline{\overline{Y}}_2+1}$. The maximum profit is $(m+n)\left(\frac{a\overline{X}_2}{\overline{\overline{X}}_2+1} + \frac{b\overline{Y}_2}{\overline{\overline{Y}}_2+1}\right)$; otherwise, the optimal prices are given by $P_X = \frac{a}{\overline{\overline{X}}_1+1}$ and $P_Y = \frac{b}{\overline{\overline{Y}}_1+1}$ with profit: $m\left(\frac{a\overline{X}_1}{\overline{\overline{X}}_1+1} + \frac{b\overline{Y}_1}{\overline{\overline{Y}}_1+1}\right) + n\left(\frac{a\overline{X}_2}{\overline{\overline{X}}_1+1} + \frac{b\overline{Y}_2}{\overline{\overline{Y}}_1+1}\right)$.

Proof of Lemma 9:
If the service provider uses the two-part tariff pricing by setting $P_X > 0$, $P_Y > 0$, and $P > 0$:

The first-order conditions for optimality of high-demand/low-demand consumer's optimization problem yield:

$$\frac{a}{X_1*+1} = P_X \quad \Rightarrow \quad X_1* = \frac{a}{P_X} - 1 \tag{28}$$

$$\frac{b}{Y_1*+1} = P_Y \quad \Rightarrow \quad Y_1* = \frac{b}{P_Y} - 1 \tag{29}$$

$$\frac{a}{X_2*+1} = P_X \quad \Rightarrow \quad X_2* = \frac{a}{P_X} - 1 \tag{30}$$

$$\frac{b}{Y_2*+1} = P_Y \quad \Rightarrow \quad Y_2* = \frac{b}{P_Y} - 1 \tag{31}$$

Likewise, we use divide-and-conquer technique to do the analysis. Again, we consider only the peak-hour problem first and the joint problem with non-peak-hour consideration can be solved in a similar way. Equations (28) and (30) are the peak-hour demand curves of the high-demand and low-demand consumers. Note that X_1*, X_2* are bounded at $\overline{X}_1$ and $\overline{X}_2$. First, we make the following observation: no matter what unit usage price P_X the supplier set for the service, the best subscription fee *P* it can charge the consumers is the consumer surplus of the low-demand consumers. Any subscription fee more than this is going to let the supplier lose all of the low-demand consumers. If the numbers of high-demand and low-demand consumers do not differ a lot, unless the supplier can earn a lot from the high-demand consumers alone, it is not wise for the supplier to lose all of the low-demand consumers.

Now, let's decide what the best unit usage price the supplier should charge is. First, if the supplier sets the unit usage price P_X above $\frac{a}{\overline{\overline{X}}_2 + 1}$, the supplier's optimization problem will be Max *m* ($P_X X_1$*) + *n* ($P_X X_2$*) + (*m* + *n*) *P* = Max *m* (*a* - P_X) + *n* (*a* - P_X) + (*m* + *n*) $\int_0^{\frac{a}{P_X}-1}\left(\frac{a}{X_2+1} - P_X\right)\mathrm{d}X_2$ =Max (*m* + *n*) *a* log($\frac{a}{P_X}$). It is clear that to maximize this equation the supplier will have to minimize P_X and therefore the best price P_X in this interval is $\frac{a}{\overline{X_2}+1}$ with the maximum profit achievable (m + n) a log ($\overline{X_2}$ +1).

Second, if the supplier sets the unit usage price P_X between $\frac{a}{\overline{X_1}+1}$ and $\frac{a}{\overline{X_2}+1}$, the supplier's optimization problem will be Max m ($P_X X_1^*$) + n ($P_X X_2^*$) + (m + n) P = Max m (a - P_X) + n ($P_X \overline{X_2}$) + (m + n) $\int_0^{\overline{X_2}} \left(\frac{a}{X_2+1} - P_X \right) \mathrm{d}X_2$ =Max ma - m($\overline{X_2}$ +1)P_X + (m + n) a log($\overline{X_2}$ +1). Since m($\overline{X_2}$ +1) > 0, we know that the best price P_X in this interval is $\frac{a}{\overline{X_1}+1}$ with the maximum profit achievable ma $\frac{\overline{X_1}-\overline{X_2}}{\overline{X_1}+1}$ + (m + n) a log ($\overline{X_2}$ +1).

Third, if the supplier sets the unit usage price P_X below $\frac{a}{\overline{X_1}+1}$, the supplier's optimization problem will be Max m (P_X X_1^*) + n (P_X X_2^*) + (m + n)P = Max m (P_X $\overline{X}$) + n (P_X $\overline{X}$) + (m + n) $\int_0^{\overline{X_2}} \left(\frac{a}{X_2+1} - P_X \right) \mathrm{d}X_2$ = Max $m\left(\overline{X_1}-\overline{X_2}\right)$ P_X + (m + n) a log($\overline{X_2}$ +1). It is clear that to maximize this equation the supplier will set the price at $\frac{a}{\overline{X_1}+1}$ with the maximum profit achievable ma $\frac{\overline{X_1}-\overline{X_2}}{\overline{X_1}+1}$ + (m + n) a log ($\overline{X_2}$ +1).

Now, we are ready to sum up the case when the service provider uses two-part tariff pricing by setting P_X > 0, P_Y > 0, and P > 0. Based on an analysis similar to the above on the joint problem inclusive of non-peak-hours, we know that the supplier can set the optimal price $P_X = \frac{a}{\overline{X_1}+1}$, $P_Y = \frac{b}{\overline{Y_1}+1}$, and subscription fee P equal to the consumer surplus of the low-demand consumers, with the maximum profit achievable m [$a \frac{\overline{X_1}-\overline{X_2}}{\overline{X_1}+1}$ + $b \frac{\overline{Y_1}-\overline{Y_2}}{\overline{Y_1}+1}$] + ($m$ + n) [a log ($\overline{X_2}$ +1) + b log($\overline{Y_2}$ +1)].

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